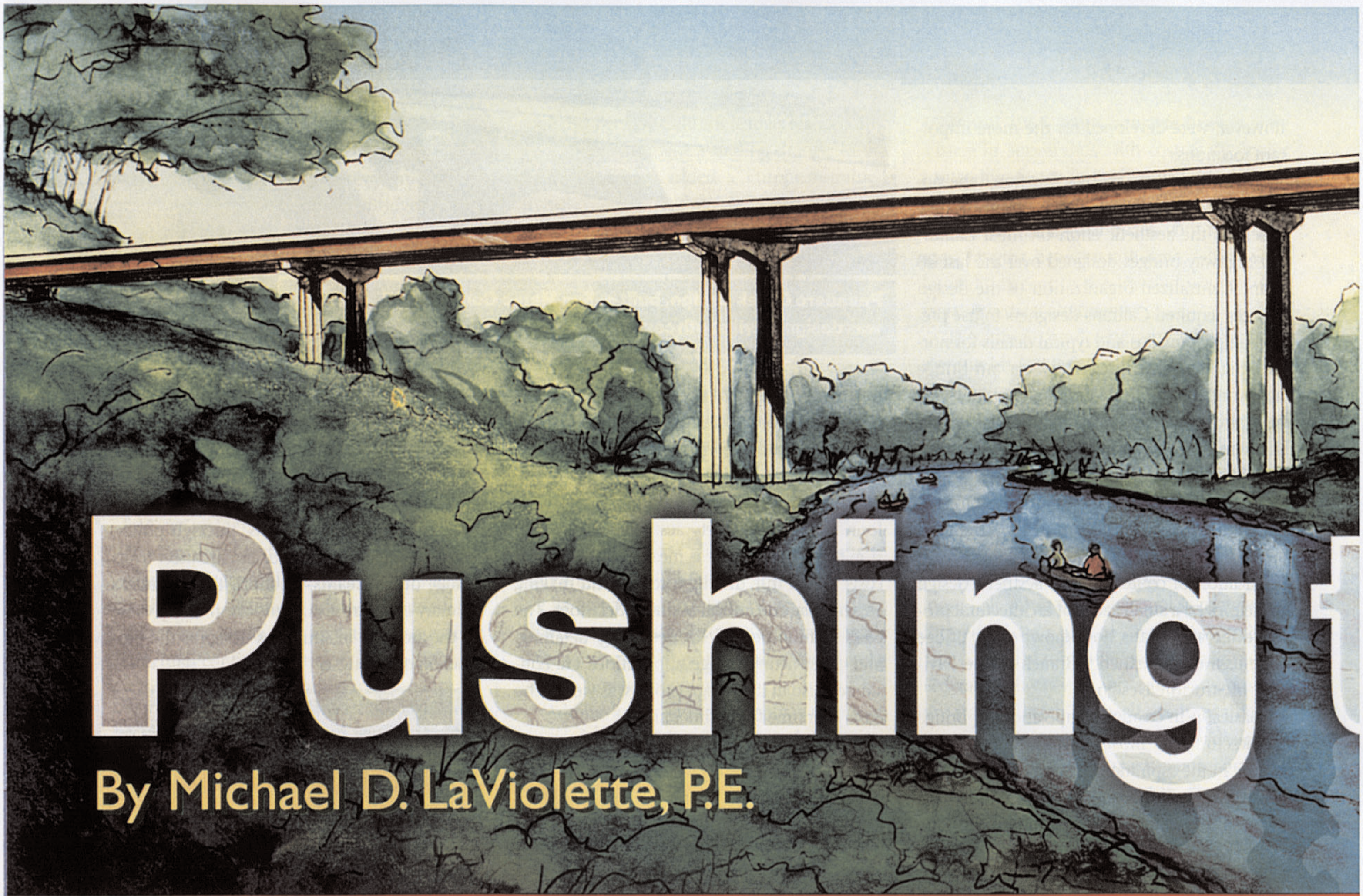

Pushing t

By Michael D. LaViolette, P.E.

■ Incremental launching construction method gains acceptance

Sometimes the simplest bridge designs come in the most complex engineering and construction packages.

As the winter of 2002/2003 approaches, the finishing touches will be added to a bridge in north-central Iowa that has pushed the limits of conventional structural engineering and construction technology.

Those who drive across the new U.S. 20 Iowa River Bridge near Steamboat Rock will be pleased with a structure that trims 15 miles — and 30-plus minutes through small communities — off their previous commute between I-35 and Waterloo. Those who canoe under the structure probably won't notice its existence, but those who orchestrated the carefully sequenced launch of 10 spans of structural steel will marvel at what they've accomplished.

"This bridge is certainly not business as usual," said Bob Younie, the Iowa Department of Transportation's (IaDOT) District 1 construction engineer. That's a message he's been sharing with all interested and involved parties since the I-girder bridge design and incremental launching construction method were agreed upon in the mid-1990s.

This project is a major milestone in the state's program to upgrade U.S. 20 to four lanes from Dubuque on Iowa's eastern border to Fort Dodge, 200 miles due west. Environmental sensitivity and economics were overriding design directives. For the project, HNTB Corporation, design and construction consultant for the project, worked closely with the IaDOT and the Federal Highway Administration to meet multiple objectives in designing the bridge.

The bridge site is located on 10 acres in the Iowa River Greenbelt, an area of historic, ecological, and archaeological significance. In addition to being a favored spot for canoeists and other outdoor enthusiasts, the woodland is a roosting habitat for bald eagles, and the river is home to three endangered or threat-

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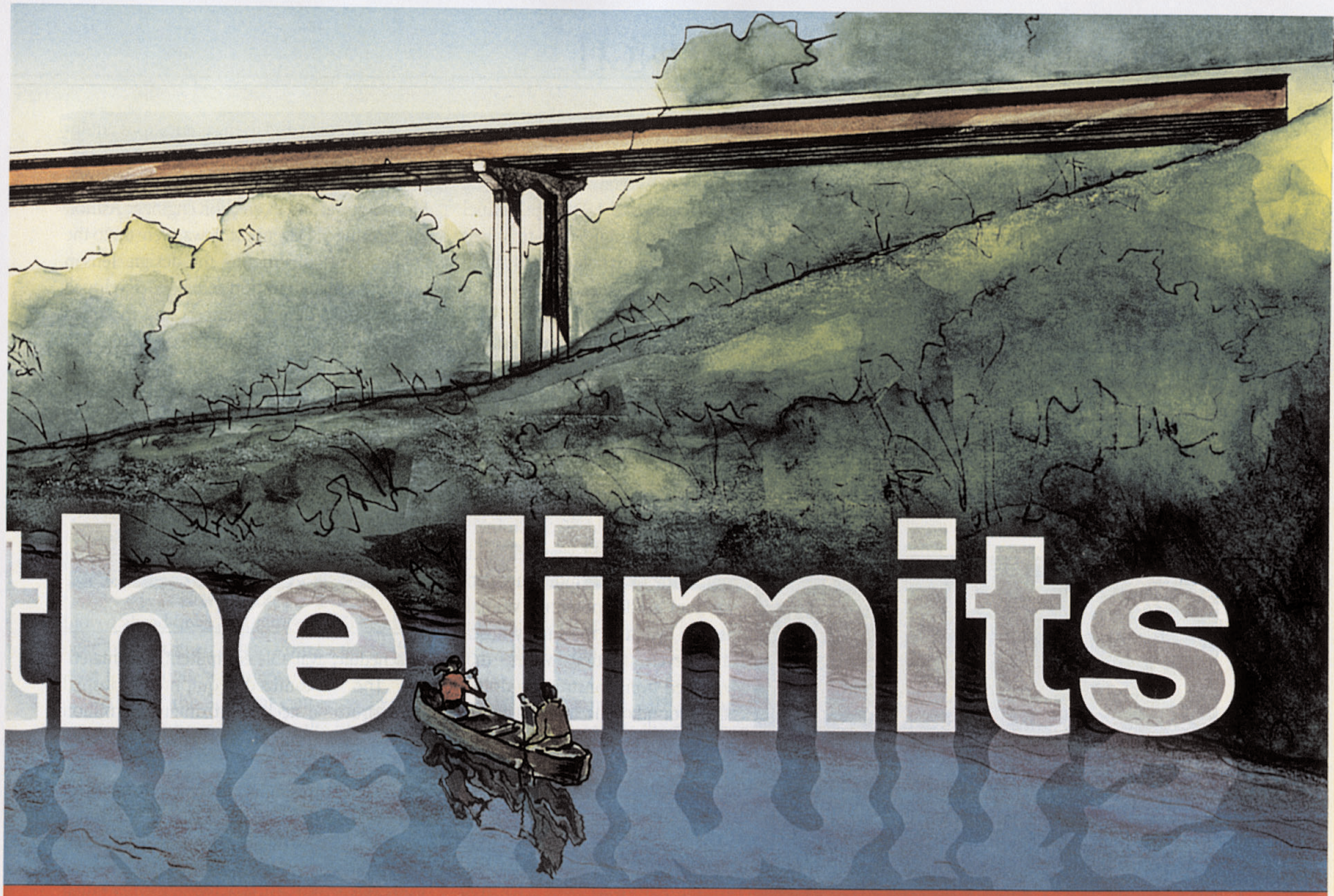
The new U.S. 20 Iowa River Bridge's simple profile blends well with the natural surroundings of the Iowa River Greenbelt (left). Because the area is home to bald eagles and other protected animal and plant life, the steel I-girder bridge was designed for minimal impact to the valley in which it is located (right).



the limits

ened species of freshwater mussels. Corridor studies for the bridge project began in 1968, and residents were vocal about their desire to preserve the site's natural resources.

"From an engineering standpoint, this project was not just a structural challenge," said HNTB project manager and project engineer Dave Rogowski, with the Kansas City, Mo., office. "It required innovative aesthetic, geotechnical, hydraulic, and environmental solutions as well."

In 1996, the site was selected from among three considered, and six alternative structure types and erection methods were evaluated. The IaDOT did not want a signature bridge design, so arch, suspension, and cable-stay options were eliminated quickly. The client's desire to build a bridge with minimal impact — visual or environmental — on the scenic area led to the selection of an incrementally launched, steel I-girder superstructure.

While it had never been employed for a steel I-girder system of this magnitude, the incremental launching technique had been used successfully for concrete box structures in Europe and for steel box girders for railroad bridges in various parts of the United States.

"IaDOT may have been skeptical about the process initially, but … gained confidence that we would deliver," Rogowski said. "The concept was sound, but the challenge came in building this bridge type in a way that had not previously been proven."

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The steel I-girder design is slender and low-profile; its longer spans reduce the number of piers needed, minimizing visual obstructions at river level. Weathering steel was selected for two reasons: it blends seamlessly into the natural surroundings, and it eliminates the need for future painting. What makes this bridge truly unique, however, is the use of launching as the method of construction.

Erected as two parallel, 39-foot-wide deck structures, the bridges consist of five equal spans of 302 feet and one, 60-foot precast concrete jumpspan at each end of the bridge. The deck structures are supported on six cast-in-place reinforced concrete piers and two end abutments. Each steel deck structure consists of a system of four, 11-foot-four-inch-deep I-girders spaced at 12-foot centers. The 1,630-foot bridge will carry traffic approximately 137 feet above the Iowa River.

The bridge contains a sealed drainage system to collect storm water. A pair of 14-inch-diameter pipelines run the length of each structure and carry runoff to a storage basin near the west abutment. The basin collects

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moved ahead quickly. A temporary "launching nose" was attached to the front of the leading span to guide its placement and to reduce the deflection of the 302-foot cantilever. Temporary roller bearings placed on the bridge piers assisted with the process of rolling the sections across the valley.

Launching of the westbound bridge began in late January of this year. Favorable weather conditions aided the project schedule, and the launch of the tenth and final span was completed in late March. The launching skid was removed, and the full length of the superstructure was jacked up to remove the rollers before being placed onto permanent bearings on the piers.

Doug McDonald, IaDOT's resident construction engineer for the project, noted that the daily interaction and close collaboration among all parties helped the highly complex construction process proceed on a nearly year-round basis.

In the project's final months of construction, even more customized engineering solutions will be employed. To build the bridge's concrete deck, the construction team developed a way to eliminate the usual method of operating a crane along the ground. A custom-designed mobile crane will start at one abutment and then run the length of the girders to assist with installing deck drain piping, forming the deck, and installing the slab reinforcing.

"With the Iowa River Bridge, we pushed the limits of conventional construction techniques," Rogowski said. "We also provided the client and the community with a bridge that [is] aesthetically pleasing, cost-effective, and [that has been] constructed without compromising the surrounding environment."

Already, the bridge blends with its natural surroundings. "As you view the bridge today, you see the trees growing right alongside it," McDonald said. "Once we plant over the workpads and restore the project site, the bridge breaking out of the trees will be the only visual cue that this engineering and construction feat ever took place."

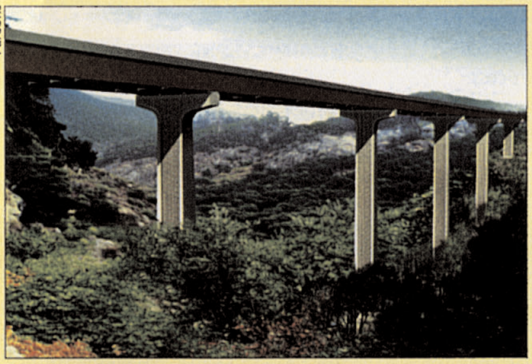
The uniqueness of the launched girder concept continues to draw considerable public and professional interest. A Web site was developed to document construction progress on the Iowa River Bridge. Construction photos are

Another example

The incremental adaptation of the Clifford Hollow Bridge

By Jim Bergeron, P.E., and Laurie Sawicki

Parsons



Rendering of the redesigned Clifford Hollow Bridge. Launching begins next month.

Sometimes innovation is simply a creative adaptation of a traditional process. In its engineered redesign of the Clifford Hollow Bridge in Hardy County, W.Va., bridge engineers with Parsons (hired to redesign the bridge to accommodate the erection scheme) put this concept to good use.

The original design of the Clifford Hollow Bridge called for the conventional erection of the superstructure: sequential erection of the girders with the use of cranes from below. But because of high piers and restricted access to the jobsite, the Parsons' engineers proposed an alternate scheme to erect the six-span continuous structure. This modified scheme involves assembling the superstructure at the western approach and incrementally launching the structure across the piers into final position. After the superstructure is in place, the concrete deck will be formed and placed conventionally.

For this innovative redesign, they drew upon their experience with concrete segmental construction. Working with contractor Dick Corporation, designer HDR Engineering, and owner West Virginia Department of Transportation, Parsons' engineers adapted their work with launching gantries on concrete segmental construction to address the challenges of erecting the bridge.

Basically, Parsons had two tasks for this job. First, it needed to redesign the structure to accommodate this kind of erection scheme. Second, the firm needed to design and develop all of the equipment necessary to launch the structure, as well as outline the procedures for launching. In effect, the company's engineers made the overall structure design simplified in detail.

The modified scheme

Essentially, Parsons' redesign uses an incremental launch process to take high-capacity cranes out of the equation altogether. While the contractor still needs some crane access to build the piers, there's no longer a need for tremendous crane capacity and high booms to erect the steel structure. "We don't need to position huge cranes in the valley of the Hollow," said Allan Brayley, P.E., runoff and allows solid materials, primarily silt and roadway salt, to settle. The materials then can be dredged and removed from the site.

Four of the piers and the two abutments are constructed on driven H-piles. To eliminate any encroachment in the river, the piers adjacent to the river are founded on eight-foot-diameter drilled shafts. The bridge design, however, was not the only big decision to be made by client and consultant. The determination of how to construct the I-girder bridge in a valley that was steep, deep, and environmentally protected required innovation from the designers and cooperation from all stakeholders.

Younie referenced his "It's not business as usual" caution often as he and HNTB engineers explained their bridge construction vision to potential contractors. Several meetings among designers, contractors, and IaDOT personnel were held during the design phase to solicit contractor input. This input helped to establish the size, location, and slope of access roads and crane workpads.

"We were not allowed to build haul roads in the project area or build a temporary structure across the river to deliver the large structural components into the valley," Rogowski said of construction mitigation restrictions. "The protected mussel species played the biggest role in keeping us out of the river.

"We [also] had to build a containment system that would keep all fluids out of the river, including accidental fuel spills, potential vandalism to hydraulic machinery hoses, and even natural water that emerged from constructing drilled shaft foundations through lenses of water above the rock formations."

The 10-acre site also was segmented into east- and west-slope construction zones. A "winter shutdown" period was designated that prohibited heavy construction activity from November 1 through April 15 on the west slope near the eagles' roosting area. The east slope was monitored during that same period to determine if noise or other construction-related activity would disrupt the bald eagle roosting habits. Monitoring activities showed that the construction had no adverse effects on the eagles' behavior.

A number of different zones on the site, which were identified in the plans, required specific site-clearing procedures and environmental protection. Minimal access paths were cleared into the valley, and these will be removed and restored following completion of the bridge. A temporary crane workpad was constructed in the east river bottom above the high-water elevation to minimize the risk of damage to both the environment and to the contractor's equipment.

Contractor Jensen Construction of Des Moines, Iowa, and its erection engineer, Ashton Engineering of Davenport, Iowa, were up to the challenge of constructing the design. Jensen used the general erection sequence developed by the bridge design engineers and modified some of the roller and guidance systems to suit its schedule, available equipment, and materials. The customized equipment pushed more structural steel (approximately 5 million pounds per bridge) than has ever been launched before.

"We had to build a containment system that would keep all fluids out of the river."

An HNTB resident construction engineer has been onsite since the $20-million bridge was let for construction in June 2000. Construction began three months later, and the bridge is scheduled to meet its promised "open to traffic" date of November 2002.

Construction of the substructure elements started in August 2000, and preparation of a 15-foot-deep, 600-foot-long launching pit behind the east abutment was completed that November. The launching pit, dug beneath what will later become the approach roadway, was used to construct a number of temporary pile bents where sections of the I-girder superstructure were be assembled on rollers and later pushed incrementally across the piers.

Steel assembly for the eastbound bridge began in June of last year. After Jensen completed the steel erection on each span in the launching pit — including all diaphragms and lateral bracing — the steel was launched downhill along a 0.64-percent grade, being pushed by hydraulic pistons toward the west abutment at a pace of approximately one foot per minute.

Following adjustments to the steering mechanism to ensure the spans were guided in the proper alignment, the launching process

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Halfway through the launch of the eastbound bridge in fall 2001, the girders rested atop the piers that straddle the Iowa River (left). The temporary launching nose, weighing more than 150,000 pounds, landed on the forward pier and righted the structure vertically as the launch progressed (above right).

updated monthly. For additional information, see www.iowariverbridge.org.

With pushing the limits — and succeeding — comes the knowledge that the practical application of incremental launching of a long-span steel I-girder bridge is now proven. It's a point that won't escape HNTB engineers as they take on their next site-constrained bridge design challenge.

Already, the technique is being considered for its applicability to a bridge replacement project in southwestern Ohio where the bridge will span a river valley that sees heavy recreation use and is adjacent to a Native American enclosure. In the meantime, drivers and environmentalists in Iowa will enjoy the simple outcome of a complex but largely transparent engineering solution. ■

Michael D. LaViolette, P.E., *based in HNTB's Ames, Iowa office, has served as the firm's resident construction engineer for the construction phase of the U.S. 20 Iowa River Bridge since mid-2000. He has worked for HNTB for 10 years and has participated in the design of numerous bridge projects in the central United States. He can be reached at (515) 291-9035, or at mlaviolett@hntb.com.*

assistant technical director with Parsons' Denver office. "The pieces we're raising for the piers are a lot smaller, so the magnitude of this part of the project is a lot less substantial."

Eliminating high-capacity cranes also reduces the project's vulnerability to wind and other weather conditions. "We still have some susceptibility to wind, but not as much," said Brayley. "We're launching four girders braced together. And while we don't want to launch in high wind, we're not constrained by the same wind limits as we would be using cranes."

Launch time

Before the launching process can begin, the girder segments will be assembled. Dick Corporation will build four girder segments, including stringers and bracing, on the western approach. At a minimum, the first seven field sections (spans five and six) will be spliced fully. Then, a stay cable system will be installed. To provide support to the girders as they cantilever 275 feet to successive supports.

Incremental launching of the structure proceeds successively, as crews add girder segments to the rear and then launch the piece forward. "The process allows the crew to incrementally assemble the steel plate girders on the abutment and make the splices right there on ground," said Scott McNary, P.E., director of technology with Parsons' Denver office. "All of the splices and cross bracing are assembled. Everything is done completely before the crew pushes it out."

Approximately four hundred feet of the structure will be pre-erected at one time on a launch track system. And then the launch system will grab the steel bridge segment and push it along the track with hydraulic cylinders. Roller supports are installed on top of each pier, which will allow the bridge to roll into place.

The rollers must accommodate a capacity of about 250 tons, controlled by the reaction caused by the cantilever at the lead pier. Tapered plates will be located at each change in bottom flange thickness to allow passage over the rollers.

An unconventional process

While geometrics can sometimes be problematic, the geometry of the Clifford Hollow Bridge actually lends itself to the incremental launch process.

The alignment of the structure is straight, but the profile varies — the bridge begins on a negative 2.67-percent tangent slope with a transition to a 380-meter vertical sag curve, which begins in span four. Inherently, the lead section of the launch is curved upward; this is actually advantageous in accommodating deflections as each pier is reached." At one end of bridge, there's some vertical curvature," said Brayley. "We can use that curve like a launching nose, and as we launch the bridge, it helps deflect the girders to the rollers at the next pier."

With a negative grade, forward launching will require only a nominal force. Accordingly, the launch system capacity is controlled by restraint. It must ensure a controlled launch and allow reverse launching if required.

Incrementally launching complex steel structures is somewhat unconventional in the United States — the system is more common in Europe, where designers often manipulate the roadway geometry to accommodate the erection scheme. According to McNary, the structure must have a constant grade and curvature for incremental launching to work effectively. "If a bridge is partially straight and partially curved, then launching won't work," he said.

Access to the jobsite is another factor in selecting the incremental launching process. When you have better access to the jobsite, it makes more sense to erect the structure in place with cranes, according to Parsons' engineers. But Clifford Hollow is the perfect project to use an incremental launch system because it's a straight bridge, and the access to the site is terrible."

Incremental advantages

Following are some of the benefits Parsons' engineers discovered while redesigning the erection scheme to an incremental launch system:

• **Reduced need for cranes.** Parsons anticipated difficulties with the large cranes required by the original scheme — the plan called for high-capacity cranes positioned in the valley to raise the steel pieces to the 275-foot piers. "Since the site is just one big valley, you'd have to cut into the mountain extensively to create temporary access roads for cranes and equipment," McNary said.

• **Minimal exposure to the elements.** Incrementally launching the structure eliminates issues associated with wind load. Parsons' engineers found that launch operations should be staged so that exposure to wind during critical stages is limited. Although the intent is to limit launching operations to calm weather conditions, the bridge can be launched in a maximum wind speed of 30 mph.

• **Improved safety.** Incrementally launching eliminates much of the high-level work associated with the erection of steel structures. First, there's more efficiency with erection when you're building close to ground. Second, the safety of the crew can be compromised as girders swing with the wind.

"It's expensive to implement adequate fall protection," said McNary. "One of the big advantages of launching incrementally is that the erection crew works behind the abutments. They're only five or ten feet off the ground, as opposed to [hundreds of] feet."

• **Increased cost effectiveness.** While there may be relatively high costs for designing and developing the launch equipment, the comparative prices of high-capacity cranes can be much steeper — not to mention the added costs of positioning them in sensitive or inaccessible locations.

Currently, Parsons is finishing the design of erection equipment for the Clifford Hollow Bridge. The firm anticipates that launching of the structure will begin next month. ■

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